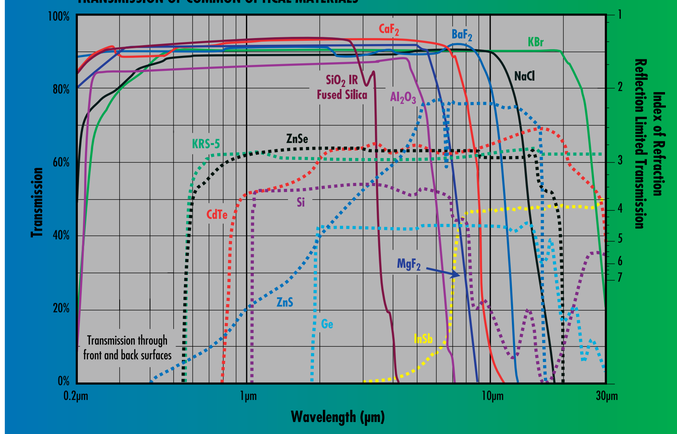
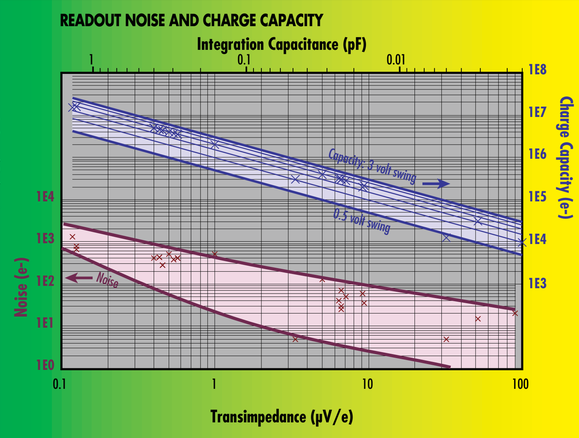
The Infrared Wall Chart

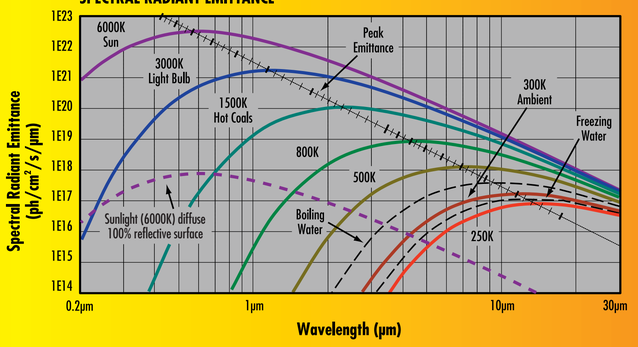
TRANSMISSION OF COMMON OPTICAL MATERIALS



READOUT NOISE AND CHARGE CAPACITY



SPECTRAL RADIANT EMITTANCE



SELECTED FORMULAS FOR BLACKBODY RADIATION

Planck's Law for photon emittance

$$Q(\lambda,T) = \frac{2\pi c}{\lambda^4\left(\exp\left(\frac{hc}{\lambda kT}\right)-1\right)} \quad \text{(photons cm}^{-2}\text{ sec}^{-1}\mu\text{m}^{-1}\text{)}$$

$$Q(\lambda,T) = \frac{C_1}{\lambda^4\left(\exp\left(\frac{C_2}{\lambda T}\right)-1\right)}$$

Planck's Law for radiant emittance

$$W(\lambda,T) = \frac{2\pi hc^2}{\lambda^5 \exp\frac{hc}{\lambda kT} - 1} \quad \text{(W cm}^{-2}\ \mu\text{m}^{-1}\text{)}$$

$$W(\lambda,T) = \frac{C_1}{\lambda^5\left(\exp\left(\frac{C_2}{\lambda T}\right)-1\right)}$$

Blackbody total emittance (Stefan-Boltzmann Law)

$W = \int W(\lambda,T)\, d\lambda = \sigma T^4$ (W cm^{-2})

Wien's Displacement Law

$\lambda_m T = \alpha$

λ_m = wavelength of maximum spectral emittance

α = 2897.8 μm K for radiant emittance

= 3669.7 μm K for photon emittance

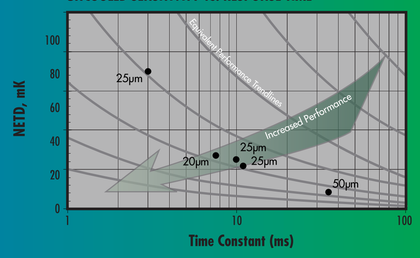
Radiant Emittance and Photon Emittance are Related by: $W(\lambda,T) = \frac{hc}{\lambda} Q(\lambda,T)$

FIGURES OF MERIT USED TO DESCRIBE THE PERFORMANCE OF A DETECTOR

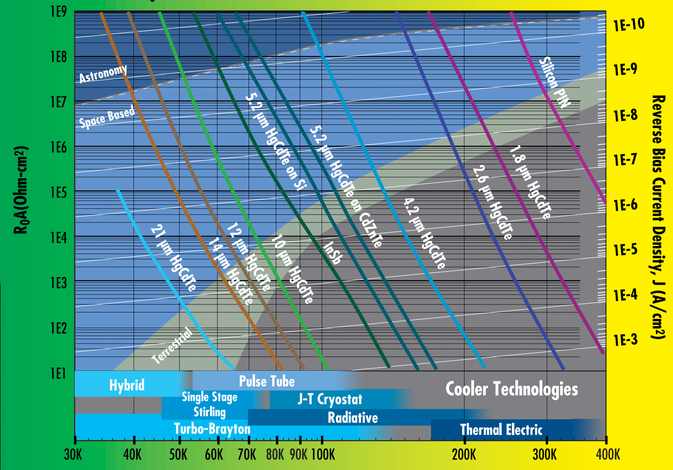
Figure of Merit	Equation	Units
• Responsivity	$R = \frac{V_s}{HA_d}$	VW^{-1}
• Noise equivalent power	$NEP = HA_d \frac{V_n}{V_s}$	W
• Noise equivalent irradiance	$NEI = \frac{QV_n}{V_s} = \frac{\text{Total Noise}}{A_d \eta T_{int}}$	photons cm^{-2} sec^{-1}
• Detector noise	$e^- = \sqrt{\frac{mkT\, A_d T_{int}}{q^2 (R_0 A)}}$	Electrons
• D-star	$D^* = \frac{(A_d \Delta f)^{1/2}}{NEP}$	(Jones) cm(Hz)$^{1/2}$W^{-1}
• Reverse bias current density	$J = \frac{kT}{q\,(R_0 A)}$	A/cm^2
• Source Radiance at the Detector	$Q_{det} \equiv Q_{source} \frac{X_t}{(4\,f\#^2)+1}$	(ph/cm^2/s/μm)
	$\equiv Q_{source} \frac{GSD^2\, A_{opt}\, X_t}{\pi A_d D^2}$	(ph/cm^2/s/μm)
• Background Limited Performance	$Blip = \sqrt{n Q A_d \eta T_{int}}$	Electrons
• FPA Noise	$\text{Total Noise} = \sqrt{(\text{Blip})^2 + (\text{Read Noise})^2 + (\text{Detector Noise})^2}$	Electrons

A_d = Detector area, cm^2
H = Irradiance, W cm^{-2}
Q = Photon incidence, photon cm^{-2} sec^{-1}
V_n = rms noise voltage
V_s = rms signal voltage
Δf = Equivalent noise bandwidth, Hz
m = 1 reverse bias, 2 zero bias
GSD^2 = Detector area projected onto the source
A_{opt} = Effective area of aperture
f# = Ratio of effective detector focal length to aperture diameter
D = Distance to source
X_t = Transmission of optical path from source to detector
η = Quantum Efficiency
n = 1 for photovoltaic, 2 for all other detectors

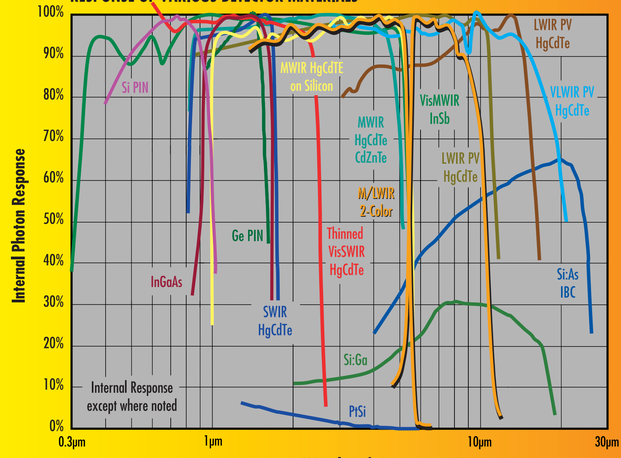
UNCOOLED SENSITIVITY vs. RESPONSE TIME



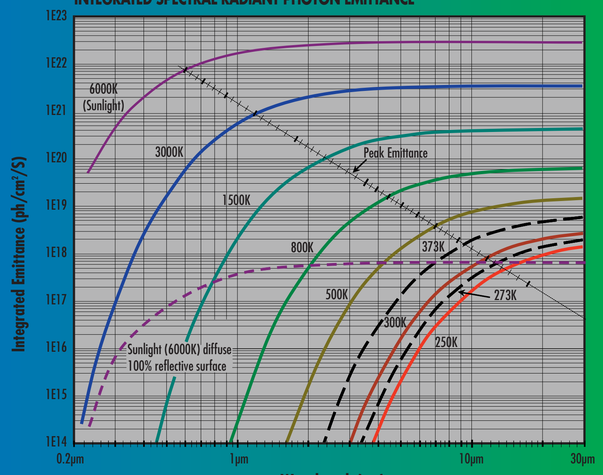
DETECTOR R_0A AND DARK CURRENT



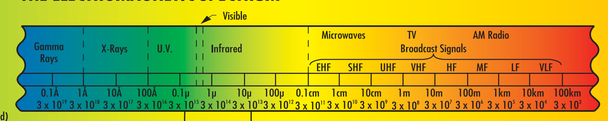
RESPONSE OF VARIOUS DETECTOR MATERIALS

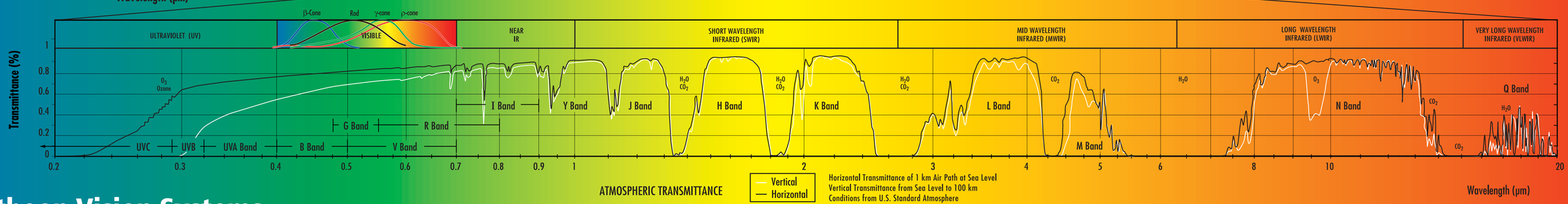


INTEGRATED SPECTRAL RADIANT PHOTON EMITTANCE



THE ELECTROMAGNETIC SPECTRUM





ATMOSPHERIC TRANSMITTANCE

Vertical
Horizontal

Horizontal Transmittance of 1 km Air Path at Sea Level
Vertical Transmittance from Sea Level to 100 km
Conditions from U.S. Standard Atmosphere

SELECTED PHYSICAL CONSTANTS

Speed of light in vacuum	c	2.998 x 10^8 m sec^{-1}
Elementary charge	q	1.602 x 10^{-19} Coul
Electron rest mass	m	9.109 x 10^{-31} kg
Planck's constant	h	6.626 x 10^{-34} J sec
Boltzmann constant	k	1.381 x 10^{-23} J K^{-1}
Stefan-Boltzmann constant	$\sigma = \left(\frac{C_1}{C_2^4}\right)\left(\frac{\pi^4}{15}\right)$	5.670 x 10^{-8} W m^{-2} K^{-4}
First radiation constant	$C_1 = 2\pi hc^2$	3.742 x 10^4 W cm^{-2}μm^4
	$C'_1 = 2\pi c$	1.884 x 10^{23} sec^{-1}cm^{-2}μm^3
Second radiation constant	$C_2 = hc/k$	1.439 x 10^4 μm K

Raytheon Vision Systems

For furthur information contact: Raytheon Vision Systems • 75 Coromar Drive, Goleta, California 93117 • USA • http://www.raytheon.com • RVSmarketing@raytheon.com

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